APHIS MIGRATION AND THE EFFICIENCY OF THE TRAPPING METHOD

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(With 5 Text-figures)

Reproducible results were obtained when adhesive traps for aphides were placed at the same height in different parts of a potato field. The total catches in different localities in different seasons can therefore justifiably be compared. During the summer dispersal flights, different species flew at different heights, so traps at one height only are not suitable for comparing the relative abundance of different species. There was less variation in numbers caught on traps at 3–4 ft. above the ground than on traps at 5–6 ft. or at ground-level.

During the first fortnight of July an average of 200 aphides, 1·6% of which were *Myzus persicae*, was caught on traps in the position of potato plants. Most of these were not potato aphides, but it is suggested that some of them might act as vectors of potato viruses. The number of aphides caught was roughly proportional to the volume of free air space around the traps, and as the foliage increased in density the numbers caught on lower traps decreased in proportion.

Wind-speed records within and above the crop are discussed and it is shown that conditions are often suitable for voluntary aphis flight in and near the crop on relatively windy days. Records of catches on the half-traps facing the wind and on the other halves showed that voluntary flight decreased with increasing height.

Brilliant yellow traps, coated with adhesive grease, caught more aphides than white traps, which in turn caught more than black.

The stove-pipe types of sticky aphis traps have been in use for the last 7 years to study aphis migration and its relation to the spread of potato and sugar-beet virus diseases (Broadbent, 1946; Doncaster & Gregory, 1948; Broadbent & Gregory, 1948; Broadbent, Doncaster, Hull & Watson, 1948). Two types of trap have been used, both consisting of lengths of galvanized iron stove-piping, 5 in. in diameter and painted white. The earlier type was 3 ft. long and was coated directly with a grease-banding preparation; the later type was 1 ft. long and the grease was carried on a transparent plastic cover (area 1·3 sq.ft.). Both types of trap have given valuable results in showing the time at which aphides were flying, but the significance of quantitative differences in the catches on traps at different centres or in different seasons was uncertain.

The flight of aphides is largely influenced by wind (Davies, 1936; Thomas & Vevai, 1940), and wind speeds and directions probably vary considerably at different heights near the ground (Geiger, 1927). The experiments described were conducted to determine in what manner the height of the trap above the ground affected the catch, to study wind gradients near the ground and their effect on aphis flight, to determine if the colour of the traps was of significance in attracting aphides,

and if traps placed at the same height in different parts of a potato field gave similar catches.

TRAPPING AT DIFFERENT HEIGHTS IN A POTATO FIELD

Four posts were erected in a crop of Majestic potatoes on Great Harpenden field, Rothamsted; each carried three 1 ft. long traps (Broadbent *et al.* 1948) at heights 2–14 in. (trap C), 32–44 in. (trap B), and 62–74 in. (trap A) above the soil of the potato ridge. The last height is the greatest at which the trap covers can be conveniently changed. The traps C occupied the positions of potato plants in the rows. The traps were all orientated so that the brass strips holding the covers faced north-west; thus, when the covers were examined, they could be divided into four strips which had faced north, west, east and south respectively.

The traps were erected on 19 June 1947 with thirty-four rows of potatoes (80 ft.) between the traps. They were not in operation between 7–10 July when the field was being ridged; they were then re-erected in pairs, 10 rows (24 ft.) apart, with 40 rows (96 ft.) between the two pairs. Another trap was erected, at the same height as the top traps (A) of the other four groups, in an open gangway 24 ft. wide. The covers were changed in the mornings (*c.* 7.00 a.m. G.M.T.) at varying intervals (Table 1). Total numbers of aphides were counted for each quadrant of each trap; after clearing they were examined and the number of *M. persicae* Sulz. per trap was counted (Table 1).

TABLE 1. *Total aphides and* Myzus persicae *trapped at three levels in a potato field*, 1947

			Aphides						*M. persicae*				
			Trap						Trap				
Date	No. of days	Level	1	2	3	4	Total	% of total	1	2	3	4	Total
19–23 June	4	A	16	25	11	12	64	49	0	0	0	0	0
		B	14	11	7	11	43	33	0	0	0	0	0
		C	8	6	5	5	24	18	0	0	0	0	0
		Total	38	42	23	28	131	—	0	0	0	0	0
23–26 June	3	A	47	35	53	51	186	51	0	0	0	0	0
		B	25	22	34	37	118	33	0	0	0	0	0
		C	17	10	19	12	58	16	0	0	0	1	1
		Total	89	67	106	100	362	—	0	0	0	1	1
26 June–7 July	11	A	155	144	185	190	674	35	0	0	1	0	1
		B	145	144	218	164	671	35	1	2	0	0	3
		C	170	80	180	153	583	30	0	0	0	0	0
		Total	470	368	583	507	1928	—	1	2	1	0	4
10–14 July	4	A	164	160	156	152	632	43	2	2	2	0	6
		B	120	136	117	136	509	35	0	0	1	0	1
		C	123	52	53	85	313	22	1	0	0	0	1
		Total	407	348	326	373	1454	—	3	2	3	0	8
14–18 July	4	A	246	218	184	223	871	56	73	69	42	65	249
		B	112	119	126	148	505	32	17	21	19	18	75
		C	64	34	33	49	180	12	4	4	5	3	16
		Total	422	371	343	420	1556	—	94	94	66	86	340

Table 1 (*continued*)

Date	No. of days	Level	Aphides: Trap 1	Trap 2	Trap 3	Trap 4	Total	% of total	*M. persicae*: Trap 1	Trap 2	Trap 3	Trap 4	Total
18–22 July	4	A	—	176	185	—	361	49	—	1	5	—	6
		B	—	214	112	—	326	44	—	1	1	—	2
		C	—	30	26	—	56	7	—	0	1	—	1
		Total	—	420	323	—	743	—	—	2	7	—	9
22–23 July	1	A	—	54	39	—	93	50	—	1	1	—	2
		B	—	43	38	—	81	43	—	1	0	—	1
		C	—	6	8	—	14	7	—	0	0	—	0
		Total	—	103	85	—	188	—	—	2	1	—	3
23–25 July	2	A	79	96	67	74	316	57	0	1	2	0	3
		B	51	64	35	65	215	39	0	0	0	0	0
		C	7	8	4	3	22	4	0	0	0	0	0
		Total	137	168	106	142	553	—	0	1	2	0	3
25–26 July	1	A	67	67	44	61	239	49	1	0	1	3	5
		B	48	63	55	50	216	45	0	0	0	0	0
		C	9	6	5	10	30	6	0	0	0	0	0
		Total	124	136	104	121	485	—	1	0	1	3	5
26–27 July	1	A	66	77	64	40	247	57	1	2	3	0	6
		B	43	36	35	37	151	35	1	1	1	1	4
		C	13	12	4	4	33	8	0	0	0	0	0
		Total	122	125	103	81	431	—	2	3	4	1	10
27–28 July	1	A	47	31	19	30	127	49	8	2	1	5	16
		B	30	20	21	33	104	40	6	4	0	2	12
		C	7	10	1	11	29	11	0	0	0	0	0
		Total	84	61	41	74	260	—	14	6	1	7	28
28–29 July	1	A	76	77	48	52	253	53	5	6	5	2	18
		B	59	74	34	39	206	42	0	2	2	0	4
		C	4	11	5	6	26	5	0	0	1	0	1
		Total	139	162	87	97	485	—	5	8	8	2	23
29 July–1 Aug.	3	A	122	112	87	100	421	48	10	19	7	7	43
		B	101	135	94	79	409	47	4	5	3	4	16
		C	13	9	10	15	47	5	0	1	0	0	1
		Total	236	256	191	194	877	—	14	25	10	11	60
1–4 Aug.	3	A	84	71	71	66	292	53	15	15	10	15	55
		B	49	69	50	58	226	41	8	7	9	7	31
		C	15	8	9	6	38	6	2	1	1	0	4
		Total	148	148	130	130	556	—	25	23	20	22	90
4–8 Aug.	4	A	76	80	83	93	332	52	19	12	23	23	77
		B	60	59	73	58	250	39	12	16	17	11	56
		C	19	9	14	13	55	9	4	0	6	3	13
		Total	155	148	170	164	637	—	35	28	46	37	146
8–14 Aug.	6	A	84	—	—	83	167	67	9	—	—	12	21
		B	33	—	—	38	71	29	7	—	—	5	12
		C	8	—	—	2	10	4	3	—	—	0	3
		Total	125	—	—	123	248	—	19	—	—	17	36

Table 1 (*continued*)

Date	No. of days	Level	Aphides: Trap 1	2	3	4	Total	% of total	*M. persicae*: Trap 1	2	3	4	Total
14–18 Aug.	4	A	23	—	—	25	48	63	1	—	—	1	2
		B	18	—	—	7	25	33	2	—	—	3	5
		C	1	—	—	2	3	4	0	—	—	0	0
		Total	42	—	—	34	76	—	3	—	—	4	7
18–25 Aug.	7	A	38	—	—	23	61	68	1	—	—	0	1
		B	13	—	—	14	27	30	1	—	—	0	1
		C	2	—	—	0	2	2	0	—	—	0	0
		Total	53	—	—	37	90	—	2	—	—	0	2
25 Aug.–1 Sept.	7	A	35	—	—	26	61	64	0	—	—	0	0
		B	15	—	—	12	27	28	0	—	—	0	0
		C	3	—	—	5	8	8	0	—	—	0	0
		Total	53	—	—	43	96	—	0	—	—	0	0
1–8 Sept.	7	A	41	—	—	46	87	57	0	—	—	1	1
		B	36	—	—	18	54	36	1	—	—	0	1
		C	6	—	—	5	11	7	0	—	—	0	0
		Total	83	—	—	69	152	—	1	—	—	1	2
8–15 Sept.	7	A	87	—	—	80	167	67	5	—	—	4	9
		B	39	—	—	34	73	29	1	—	—	2	3
		C	6	—	—	3	9	4	1	—	—	0	1
		Total	132	—	—	117	249	—	7	—	—	6	13
15–22 Sept.	7	A	89	—	—	72	161	67	5	—	—	4	9
		B	27	—	—	32	59	24	1	—	—	2	3
		C	8	—	—	13	21	9	3	—	—	1	4
		Total	124	—	—	117	241	—	9	—	—	7	16
22–29 Sept.	7	A	46	—	—	49	95	58	3	—	—	3	6
		B	35	—	—	25	60	36	0	—	—	0	0
		C	5	—	—	4	9	6	0	—	—	0	0
		Total	86	—	—	78	164	—	3	—	—	3	6
29 Sept.–6 Oct.	7	A	48	—	—	28	76	69	1	—	—	1	2
		B	12	—	—	16	28	25	1	—	—	3	4
		C	3	—	—	4	7	6	0	—	—	1	1
		Total	63	—	—	48	111	—	2	—	—	5	7

The four banks of three traps were operated from 19 June to 8 August, excepting 7–10 and 18–23 July, i.e. a total of 42 days. The total number of aphides caught over that period is given in Table 2, together with the percentage that each catch forms of the total on the three traps on each post. These percentages are very similar for the four traps at each level. Table 3 gives the deviation from the mean of each total catch and these differences expressed as percentages of the mean. In the past, traps of this type have always been used between the limits set by traps A and B, so a better idea of their reliability is obtained by omitting the low traps (C) from consideration. Then the highest deviation from the mean of A + B is less than 5 % of the mean.

TABLE 2. *Total aphides trapped 19 June–8 August 1947, with the percentage of the total at each level*

Trap ...	1		2		3		4		Mean	
	No.	%	No.	%	No.	%	No.	%	No.	%
A	1245	49	1193	50	1072	46	1144	47	1164	48
B	857	33	952	39	899	39	915	38	906	37
C	469	18	255	11	342	15	372	15	359	15
Total	2571	—	2400	—	2313	—	2431	—	2429	—

TABLE 3. *Deviations from the mean expressed as numbers and as percentages of the mean*

Trap ...	1		2		3		4		Mean
	No.	%	No.	%	No.	%	No.	%	No.
A	+ 81	+ 7	+ 29	+ 3	− 92	−8	−20	−2	1164
B	− 49	− 5	+ 46	+ 5	− 7	−1	+ 9	+1	906
C	+110	+31	−104	−29	− 17	−5	+13	+4	359
Total	+142	+ 6	− 29	− 1	−116	−5	+ 2	0	2429

Two groups of traps, numbers 1 and 4, were operated until the potatoes were lifted (6 October). Table 4 gives the total catches for these six traps over the whole season.

TABLE 4. *Total aphides on traps 1 and 4, 19 June–6 October, with the percentage of the total at each level*

Trap ...	1		4		Mean	
	No.	%	No.	%	No.	%
A	1736	52	1576	51	1656	52
B	1085	33	1111	36	1098	34
C	511	15	410	13	461	14
Total	3332	—	3097	—	3215	—

The similarity between total catches, over the individual periods and over the whole period, justifies the comparison of catches at different centres so long as the traps are erected at the same height and under similar conditions. It is not often, however, that total catches are compared; interest usually centres on individual species, and especially upon *M. persicae*. Table 5 gives the total catches of *M. persicae*: although the percentage deviation from the mean of traps A + B was between 4 and 14% of the mean, the periodic and total catches on the four traps corresponded with sufficient closeness to enable catches at different centres to be compared, again so long as the traps are operated under standard conditions.

The greatest variation between traps at any one level was between those near the ground (C); the differing conditions of shelter and of wind eddies at this level must have profoundly affected the catch. The catches on the middle traps (B) were more

comparable than were those on the upper traps (A), for total aphides (1–5% deviation in B, 2–8% in A) and for *M. persicae* (2–16, 2–20%).

TABLE 5. *Total* Myzus persicae *trapped, with the percentage of the total at each level*

Trap ...	1		2		3		4		Mean	
	No.	%	No.	%	No.	%	No.	%	No.	%
					19 June–8 August					
A	134	69	127	67	96	60	122	71	120	67
B	49	25	58	30	52	32	43	25	51	28
C	11	6	6	3	13	8	7	4	9	5
Total	194	—	191	—	161	—	172	—	180	—
					19 June–6 October					
A	159	66	—	—	—	—	148	69	154	67
B	63	26	—	—	—	—	50	23	57	25
C	18	8	—	—	—	—	17	8	18	8
Total	240	—	—	—	—	—	215	—	229	—

TABLE 6. *Total aphides and* Myzus persicae *trapped at level A; traps 1–4 over potatoes, trap 5 over adjacent bare ground*

		Total aphides					*M. persicae*				
Date	Trap ...	1	2	3	4	5	1	2	3	4	5
19–23 June		16	25	11	12	17	0	0	0	0	0
23–26 June		47	35	53	51	28	0	0	0	0	0
26 June–7 July		155	144	185	190	233	0	0	1	0	1
10–14 July		164	160	156	152	157	2	2	2	0	1
14–18 July		246	218	184	223	184	73	69	42	65	59
Total		628	582	589	628	619	75	71	45	65	61

Table 6 gives the catches from trap 5 from 19 June to 18 July, compared with the four A traps above the crop. It is clear that, with traps at the height normally used, similar catches of total aphides or of *M. persicae* are obtained whether the trap is above the crop or above adjacent bare ground.

DISTRIBUTION OF SPECIES AT DIFFERENT HEIGHTS

The catches over 19 trapping days between 26 June and 18 July have been examined in greater detail and the numbers of the predominant species counted. The three commonest species were *Metopolophium dirhodum* (Walk.), *Cavariella aegopodii* (Scop.) and *Myzus persicae*. Black aphides were present in large numbers, but because of the difficulty of identifying these with any certainty, they have been grouped together and called '*Aphis fabae* complex'. The three species plus the '*A. fabae* complex' comprised 68% of the total catch on the upper traps (A), 75% on the middle (B), 81% on the lower (C), and 73% of the total catch on all traps.

In order to compare species, the numbers have been converted to percentages of the total at the three levels for each species (Fig. 3). It is obvious that during this period the four species tended to fly at different levels. *Myzus persicae* and *Metopolophium dirhodum* were more numerous on the upper traps, *Cavariella aegopodii* on the lower traps, at least during the peak period of flight for this species (26 June–7 July). From the catches on the A traps it would seem that, over the period under consideration *Myzus persicae* (256) and *Cavariella aegopodii* (229) were present in approximately equal numbers, whereas on all the traps at the different levels *C. aegopodii* (827) was more than twice as numerous as *Myzus persicae* (352). Thus traps situated at the height of 6 ft. cannot be used to compare the relative abundance of different species. In studying the spread of virus disease in a field, aphides in the air near the crop are of particular interest, and it is important to note that the middle traps (B) gave the most consistent results, since the percentages of each species and of total aphides occurring on these traps varied less than those either on upper or lower traps. It has already been shown that there was less variation in total numbers on the middle traps than on the others. In general, it appears that the best comparison between different centres or between species would be obtained with the traps at heights of 3–4 ft., although at this height fewer numbers are caught of certain species, including *M. persicae*. This would be a disadvantage in years when the species is not abundant, but it might be overcome by making the traps more attractive and having more than one at each centre.

Virus transmission in the field

The relatively large number of aphides of different species caught on the traps at ground level in the position of potato plants raises some interesting problems. Over the fifteen trapping days between 26 June and 14 July an average of 224 aphides per trap was caught on the C traps (Table 1). Thus it may be assumed that about 200 aphides, on the average, visited each plant during the first fortnight in July. A large number of these would test the plants by inserting their stylets, but would not necessarily stay to feed (Moericke, 1941). The testing action might be sufficient for transmission of potato virus *Y* by vector species and this may account for the large spread of the disease found in many years at different centres when potatoes are sampled in the second half of July (Doncaster & Gregory, 1948; Broadbent & Gregory, 1948), transmission which must have taken place before the potato aphides had built up large populations on the plants. It has been assumed that most of this early spread is caused by alate *M. persicae*, together with *Macrosiphum solanifolii* and *Aphis rhamni*, but other species which do not regularly breed on potatoes have been shown capable of spreading potato viruses (Whitehead, 1930, 1931; Smith, 1931; Loughnane, 1939; Bawden & Kassanis, 1947), and many common species have not been tested. Though most of the vectors, other than the potato aphides, were relatively ineffective, the large numbers present may add to the total of transmission.

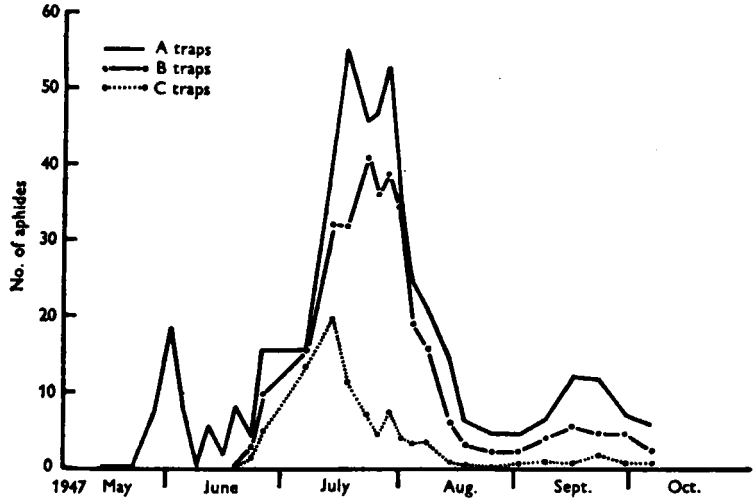

Fig. 1. Average total aphides per trap per day.

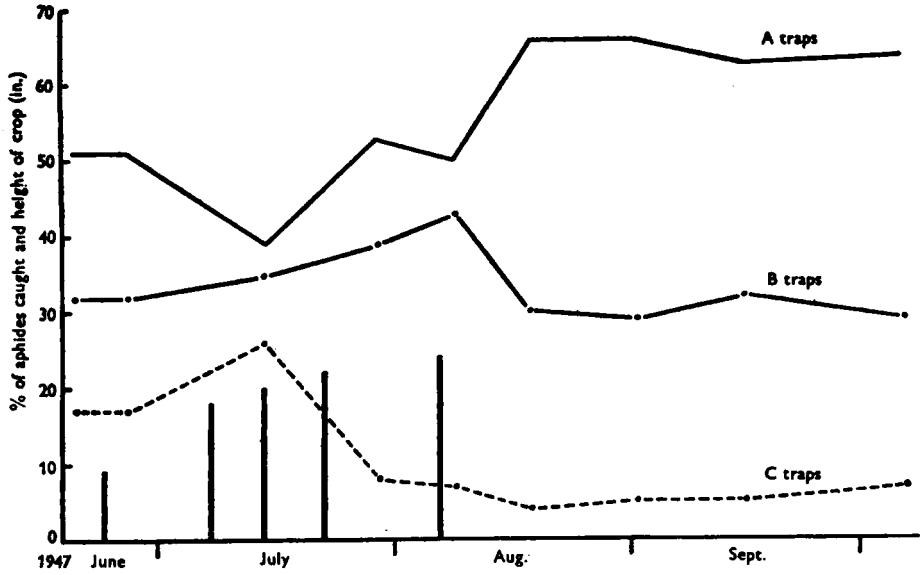

Fig. 2. Percentage of the total catch of aphides formed by the catch at each level. The vertical lines indicate the height of the crop.

HEIGHT OF CROP AND ITS EFFECT ON HEIGHT OF APHIS FLIGHT

Fig. 1 shows the average catch per day at each level. Fig. 2 shows the percentage of the total catch formed by the catch at each level, at approximately fortnightly intervals. Total numbers on the upper and middle traps reached a peak in the last fortnight of July, at the time of the summer dispersal, after which there was a rapid decline until the autumn dispersal in September, when there was a small increase.

The peak on the lower traps was a few days earlier than on the others, during the second week of July. The catches on trap 5 during May and June are also given, and indicate that the spring migration occurred in late May. The catch consisted of many species, with *Cavariella aegopodii* (19% of total) and *Phorodon humuli* (Schr.) (17%) predominating.

During the first week of July the crop was 16–18 in. high and the plants were not meeting in the rows. At this time large numbers of aphides were caught, in the proportions at the three levels of A, 35%, B, 35%, C 30%. As the crop grew and met in the rows, the proportions changed, and by the first week in August, when the haulm was dense and 20–28 in. high, were about A, 50%, B, 45%, C, 5%. By the middle of August the proportions were about A, 65%, B, 30%, C, 5%, at

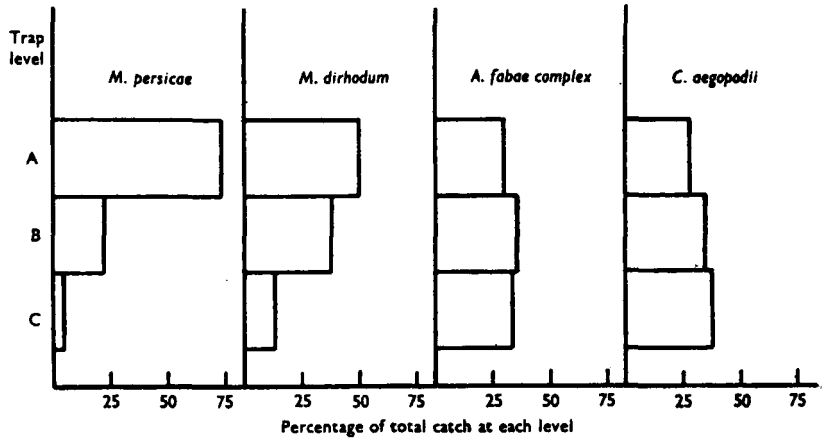

Fig. 3. Catches of the four dominant species over the peak migration period (26 June–18 July 1947).

which they remained until the end of the season, even after the haulms collapsed at maturity.

On 18 July the crop was about 24 in. high, i.e. it was about 8 in. below the B traps and 10 in. above the C traps. The plants were not touching between rows, which ran from 30° east of north to 30° west of south. There follows an estimate of the volume of free-air space between the plants around the traps, the numbers of aphides caught over periods during which the measurements were made, and the number of aphides per 1000 cu.in. of space:

Traps ...	1C	2C	3C	4C
18 July 1947:				
Volume (cu.in.)	22,600	10,900	9,350	14,800
Aphides trapped 14–22 July	128	64	59	95
Aphides per 1000 cu.in. of space	5·7	5·9	6·3	6·4
1 Aug. 1947:				
Volume (cu.in.)	16,000	11,600	6,900	8,400
Aphides trapped 29 July–4 Aug.	32	28	24	27
Aphides per 1000 cu.in. of space	2·0	2·4	3·5	3·2

It is clear that as the foliage increased in density the number of aphides caught on the lower traps decreased (see also Fig. 2). The number of aphides caught was roughly proportional to the volume of free-air space around the trap, from which it may be assumed that more aphides would visit each plant in an open crop than in a close-planted one. A similar observation was made by van der Plank & Anderssen (1944) regarding thrips on tobacco.

WIND-SPEED RECORDS

Records were made on many occasions of wind speed at 1 and 2 m. above the soil with two sensitive cup anemometers. A number of readings with one of these anemometers in the crop, compared with the other at 2 m., was also made, in addition to direct readings with a hot-wire anemometer. Fig. 4 gives the wind

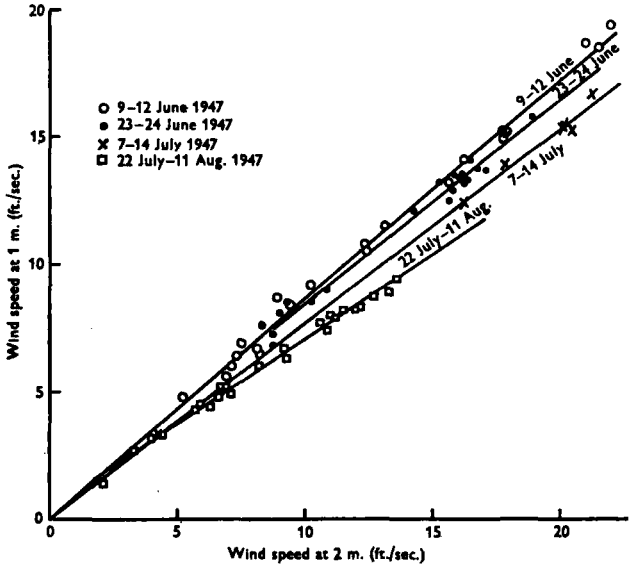

Fig. 4. Regression lines showing correlation between wind at 2 m. and at 1 m. above the ground.

speed at 2 m. plotted against that at 1 m. The relation between these two levels is linear, and the slope of the regression line varies as the crop increases in height. In Fig. 5 the wind speeds in the crop and at 10 in. above the ground before the crop was fully through, are plotted against wind speed at 2 m. In this case there is a wide scatter of points since the anemometer was placed in varying positions in the crop at different times and experienced different degrees of shelter. Davies (1936) showed in laboratory experiments that *Myzus persicae* ceased voluntary flight at wind speeds over 3·75 m.p.h. This fact has often been discussed in relation to aphis migration (Davies, 1939; Thomas & Vevai, 1940; Loughnane, 1940; Greenslade, 1941;

Profft, 1939; Heinze & Profft, 1940; Hansen, 1941; Broadbent, 1946; Doncaster & Gregory, 1948) and it has generally been agreed that aphides will only undertake voluntary flight at wind speeds under 4–5 m.p.h. But the records of wind speeds of 4 m.p.h., used in these discussions, have usually been made at recognized meteorological stations, at heights of 10 m., or have been based on the Beaufort Scale. On the average the wind speed at 2 m. is 0·78 that at 10 m. (*Meteorological Observers' Handbook*, H.M.S.O.), so that when the wind speed is 4 m.p.h. (5·9 ft./sec.)

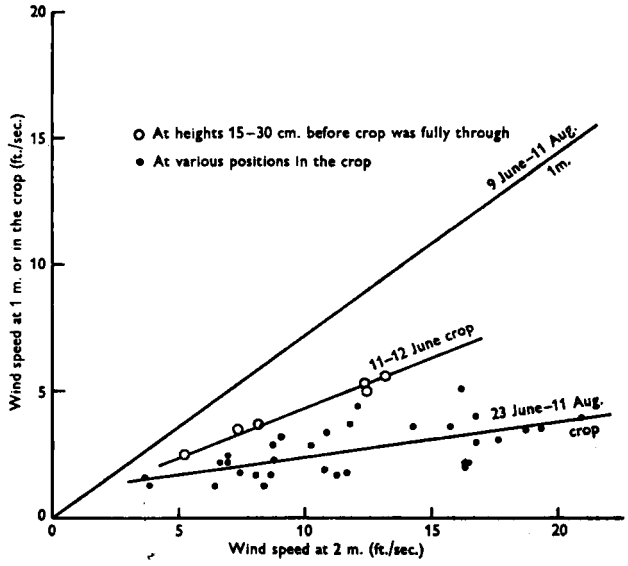

Fig. 5. Regression lines showing correlation between wind speeds at 2 m. and at 1 m. (mean from Fig. 4), and in the potato crop.

TABLE 7. *Comparative wind speeds at different heights*

	In the crop		1 m.		2 m.		10 m.	
Height	m.p.h.	ft./sec.	m.p.h.	ft./sec.	m.p.h.	ft./sec.	m.p.h.	ft./sec.
Very young	4·0	5·9	—	—	9·6	14·1	12·3	18·1
crop (June)	—	—	4·0	5·9	4·7	6·9	6·0	8·8
Dense haulm	4·0	5·9	—	—	24·7	36·2	31·6	46·4
(July–Aug.)	—	—	4·0	5·9	5·7	8·3	7·3	10·7
General	—	—	—	—	4·0	5·9	5·1	7·6

at 2 m. it will be 5·1 m.p.h. (7·6 ft./sec.) at 10 m., although the vertical gradient of wind speed is in general smaller with light winds and by day than with strong winds and by night (Giblett, 1932). When the crop has grown the ratio will be slightly different, because the effective height of the upper anemometer will be something less than 2 m. The comparative wind speeds at different heights have been read from Figs. 4 and 5 and compiled in Table 7. It will be seen that in the early part

of the season, when the plants are just coming up and are first visited by aphides, an average wind speed of 4 m.p.h. at 10 in. above the ground would require an average of 12·3 m.p.h. at 10 m. Later in the season an average wind speed of 4 m.p.h. just above the crop (at 1 m. above the soil) would necessitate an average of 7·3 m.p.h. at 10 m., and an average of 4 m.p.h. within the crop would require an average of about 32 m.p.h. at 10 m. Direct readings with the hot-wire anemometer showed that the wind speed in the crop fluctuated greatly and gusts of over 4 m.p.h. often occurred when the average wind speed at 2 m. was 8 m.p.h. However, it is clear that much voluntary aphis movement can take place among and just above the plants even on windy days (Broadbent, 1946). Also many aphides flying near the crop will be caught up in vertical wind currents and may be transported long distances involuntarily, as was pointed out by Profft (1939). The number of occasions when conditions in the crop are suitable for take-off will decrease as the wind speed increases, and this no doubt largely accounts for the occurrence of fewer aphides in the air on windy days.

DISTRIBUTION OF APHIDES ON THE TRAP SURFACES

The total numbers of aphides caught on the four sectors of traps at three heights, over the periods 25–29 July, when the trap covers were changed daily, and 4–8 August, are given in Table 8. The wind was relatively steady in direction on these

TABLE 8. *Distribution of aphides over trap surfaces; totals for four traps*

			Trap A				Trap B				Trap C			
Date	Wind direction	m.p.h.	N.	E.	S.	W.	N.	E.	S.	W.	N.	E.	S.	W.
25–26 July	S.W.–N.W.	0–5	40	30	77	92	25	50	72	69	4	10	6	10
26–27 July	W.	5–10	20	39	78	110	19	27	47	58	5	17	8	3
27–28 July	E.–S.E.	5–10	19	71	29	8	17	48	25	14	5	6	11	7
28–29 July	Varied	calm	52	55	76	70	39	43	67	57	2	8	8	8
4–8 Aug.	S.W.–N.W.	5–10+	54	11	78	189	36	9	64	141	15	14	18	8

Totals for the half-traps facing the prevailing wind and for the other half

		Trap A		Trap B		Trap C	
Date	Quadrants facing wind	Facing wind	Against wind	Facing wind	Against wind	Facing wind	Against wind
25–26 July	W.+¼ (N.+S.)	151	88	118	98	15	15
26–27 July	W.+¼ (N.+S.)	159	88	91	60	10	23
27–28 July	E.+S.	100	27	73	31	17	12
4–8 Sept.	W.+¼ (N.+S.)	255	77	191	59	25	30
	Totals	665	280	473	248	67	80
Percentage of total on each trap		70	30	66	34	46	54

days. The catches have been tabulated, giving the catches on the half-traps facing the prevailing wind and on the other halves. On the calm day 28–29 July, the catches were well distributed around the traps, and this day has therefore been omitted from the second part of the table.

On the average, the half facing the wind received 70% of the catch on the A traps, 66% on the B, and 46% on the C. At this time of the year the wind speed at 2 m. relative to that at 1 m. was 1·45:1 (Fig. 4). The total catches on the half-traps facing the wind over the 7 days were: A:B=665:473, i.e. 1·41:1. It might be inferred that these aphides were deposited at rates proportional to the wind speed, and that, therefore, the insects were randomly distributed throughout this layer of air. In Table 4 are given the catches from 19 June to 6 October, which for A and B traps are in the ratio 1·28:1. From Fig. 4 the wind speeds over this period were in a similar ratio. On the other hand, Table 1 shows that, over short periods, the number of aphides caught was often not proportional to wind speed. It is hoped that a study of the air flow around the trap and of the deposition of aphides on it in a wind tunnel will give more information on this subject.

The shelter and wind eddies operating around the traps at ground level evidently prevented the catches from bearing any direct relation to wind speed or direction.

Attraction of colour

When trapping, it is important to know if the number of any species caught on a given surface area in a given time represents the average number contained in the volume of air which had flowed past the trap in that time, or if the number is greater owing to attraction exerted by the trap, or less as a result of repulsion. The normal colour of the sticky trap was old gold (Ridgway, 1912), the colour of the coating of grease over the white paint. This colour was tested against black and primuline yellow (Ridgway, 1912) in two experiments.

In the first experiment, three 1 ft. length traps were fastened one above the other so that the top of the upper trap was 6 ft. from the ground. They were divided into four quadrants facing north, west, south and east, and each quadrant was divided into three horizontally. The resulting 4-in. squares were painted black, white and yellow, so that the three colours occurred in each quadrant. The squares were arranged so that no two of the same colour were adjacent. The plastic covers of the traps were marked into squares so that when they were removed the catch in each square could be recorded according to direction and colour.

This trap was erected near allotments at Rothamsted and cleared at weekly intervals over a period of 5 weeks. Over the whole period equal numbers of aphides were trapped on the white and black squares, whereas 1·23 times as many were caught on the yellow squares. In the first and last weeks, 11 of the 14 days were relatively calm (with average day winds under 5 m.p.h.), the wind in the second week was variable, while the third and fourth were windy (11 days with winds averaging over 5 m.p.h.). The catches showed the following ratios:

	Black	White	Yellow
Weeks 1 and 5 (calm)	1·00	0·86	1·54
Weeks 3 and 4 (windy)	1·00	1·02	1·16

Attraction would presumably be greater on calm days, when the aphides could direct their flight, and from the above figures it appeared that the aphides were attracted to the yellow squares.

The numbers of *M. persicae* caught during the 5-week period were:

	Black	White	Yellow
No.	12	14	20
Ratio	1·00	1·17	1·67

Whereas these figures showed a tendency for the aphides to be attracted to yellow, the attraction was not marked, perhaps because of the small size of the squares. Only in the very calmest weather could a trap of this kind give satisfactory results; at other times the aphides would probably be blown on to the trap at random. Another experiment was therefore carried out.

In the second experiment, three 1 ft. long traps were erected separately near the multicoloured trap, so that the top of each trap was 6 ft. from the ground. One trap was white, one black and one yellow. They were operated for a period of 40 days, their position relative to one another being changed twice, so that each occupied a given position for about one-third of the period. For 20 days the trap covers were changed daily. There was apparently no effect produced by the position of the trap. The aphides caught over the period were:

		Black	White	Yellow
Total aphides	No.	347	428	529
	Ratio	1·00	1·23	1·52
M. persicae	No.	27	33	40
	Ratio	1·00	1·22	1·48

An analysis of variance on total daily catches gave the following results:

Daily mean difference between:

Black and white traps	$2{\cdot}025 \pm 1{\cdot}109$
White and yellow traps	$2{\cdot}525 \pm 1{\cdot}318$
Black and yellow traps	$4{\cdot}550 \pm 1{\cdot}236$

Thus there was a suggestion of white being more attractive than black, and of yellow more than white, yet these differences were barely significant. Yellow, however, was significantly more attractive than black. The attraction may be greater than the differences between catches suggest because of the wind rendering choice of direction on the part of the aphides difficult, i.e. on windy days aphides would be deposited indiscriminately on the three traps. However, the ratios between catches on the three traps on days when they were changed daily were:

	Black	White	Yellow
On 13 windy days (wind over 5 m.p.h.)	1·00	1·23	1·42
On 7 calm days (wind under 5 m.p.h.)	1·00	1·25	1·41

This would suggest that wind speed had little effect on attraction. On the other

hand, if the daily catch is divided into two parts (1) that on the half-trap facing the prevailing wind, and (2) that on the other half, then the following totals are obtained:

	Facing wind			Against wind		
	Black	White	Yellow	Black	White	Yellow
No.	184	220	231	49	78	110
Ratio	1·00	1·20	1·26	1·00	1·59	2·24

Thus the catch on the half-trap facing the wind was 3·8 times that on the other half on the black trap, 2·8 times on the white and 2·1 times on the yellow. If it is assumed that most of the aphides on the side away from the wind had flown on to the trap voluntarily, then white attracted 59% more than black, and yellow 65% more than white.

It may be that black repels, rather than yellow attracts, but assuming the latter, and assuming the catch on the black trap to be due entirely to deposition by wind and that such involuntary deposition was the same for all three traps, then the numbers attracted to white and yellow traps would be:

	White	Yellow	Ratio W.:Y.
Facing wind	36	47	1·00 : 1·31
Against wind	29	61	1·00 : 2·10

In sum it appears that yellow attracts aphides, and that the brighter the colour, the greater the number attracted.

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